APPLICATION FOR UNITED STATES LETTERS PATENT

Title:

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Amendments to the Claims:

This listing of claims will replace all prior versions, and listing, of claims in the application.

What is claimed is:

Claims 1-13 (canceled)

Claims 14-40 (new) – Note: New claims are not underlined to make more legible.

14. A system for measuring the vibration characteristics of long slender structures subjected to dynamic disturbances imposed by water or wind generated loads comprising:

(a) single or plurality of independent optical fibers fastened at discrete locations along the longitudinal axis of the long slender structure;

(b) optical reflective interfaces placed at selected locations along the length of each optical fibers;

(c) laser light source projected into said optical fibers;

(d) electronic optical signal monitoring instrumentation to analyze the light signals reflected from optical reflective interfaces in the optical fibers for the purpose of determining the strain within predetermined segments along the length of the long slender structure; and

(e) fiber optics or electronic data transmission link to transport the reflected optical fiber light signal data to the electronic optical signal monitoring instrumentation.

15. The system of claim 14, wherein vibration characteristics include: vibration frequency, vibration amplitude, node to node wave length and the magnitude of the imposed peak bending strains.

16. The system of claim 14, wherein the optical fibers are located along the longitudinal axis and near the exterior or interior surface of a long slender tubular structure.

17. The system of claim 14, wherein longitudinal oriented optical fibers are located at opposite ends of an imaginary line drawn perpendicular to the longitudinal axis of the long slender structure and through the structure centroid thereby enabling the measurement of bending strains imposed during dynamic loading.

18. The system of claim 14, to include multiple set of longitudinally oriented optical fibers located on the structure near opposite ends of an imaginary line drawn perpendicular to the longitudinal axis of the long slender structure and through the structure centroid designed to capture the maximum bending strains imposed during dynamic loading.

19. The system of claim 14, used to measure the bending strain imposed by vortex induced vibrations (VIV) experienced by metal or composite production and drilling risers, tubing, ropes, and cables deployed in offshore operations in the oil industry.

20. The system of claim 14, which provides the information needed to take corrective actions to permit mitigation of potentially damaging effects of vortex induced vibrations (VIV) in long slender tubular structures used in offshore petroleum drilling and production operations.

21. The system of claim 14, wherein the electronic optical signal monitoring instrument is capable of measuring the time of flight of light reflected from an optical reflective interface and the information is interpreted to measure strain.

22. The system of claim 21, wherein the time of flight measurement instrument is an optical time domain reflectometry instrument.

23. The system of claim 21, wherein the time of flight measurement instrument is an optical frequency domain reflectometry instrument.

24. The system of claim 14, wherein an independent longitudinal oriented optical fiber is positioned to traverse back and forth along the length of the long slender structure to provide greater sensitivity to the measurement of strain using time of flight instrumentation.

25. The system of claim 14, wherein the electronic optical signal monitoring instrument measures strain using Bragg diffraction gratings.

26. The system of claim 14, wherein the optical fiber is rigidly attached to the exterior or interior surface of a metal or composite tubular using a bonding agent and the optical fiber is protected from damage by hazards imposed in the operating environment by a polymeric or elastomeric external layer.

27. A system of claim 14 wherein the optical fiber used to measure strain is constructed of glass or plastic.

28. A system of claim 14 wherein the long slender structure is a rope or cable and the bending strain and vibration characteristics measured provide the information needed to take action to permit mitigation of the potentially damaging effects of wind or water generated dynamic disturbances.

29. A system for measuring the bending and buckling characteristics of spoolable metal or composite pipe using optical fibers including:

(a) single or a plurality of independent optical fibers rigidly attached at discrete locations along the longitudinal axis of spoolable metal or composite pipe;

(b) optical reflective interfaces placed at selected locations along the length of each optical fiber;

(c) laser light source projected into said optical fibers;

(d) electronic optical signal monitoring instrumentation to analyze the light signals reflected from optical reflective interfaces in the optical fibers for the purpose of determining the strain within predetermined segments along the length of the long slender tubular structure; and

(e) fiber optics or electronic data transmission link to transport the optical fiber light signal data to the electronic optical signal monitoring instrumentation.

30. The system of claim 29, wherein longitudinal oriented optical fibers are located at opposite ends of an imaginary line drawn perpendicular to the longitudinal axis of the spoolable pipe and through the pipe centroid thereby enabling the measurement of bending strains imposed during injection of the spoolable pipe into a small diameter annulus such as an oil well or bore hole.

31. The system of claim 29, to include multiple set of longitudinally oriented optical fibers located at opposite ends of an imaginary line drawn perpendicular to the longitudinal axis of the spoolable pipe and through the pipe centroid designed to capture the maximum bending strains imposed during deployment into a small diameter annulus.

32. The system of claim 29, wherein the bending strain in the spoolable pipe is measured as the spoolable pipe buckles into numerous short wave length spiral and helical buckles inside the annulus in response to the axial compressive force imposed to push

the spoolable pipe into the annulus by a coiled tubing injector or other injection apparatus.

33. The buckling characteristics of claim 29, wherein bending strain information provides the information necessary to take action to prevent the spoolable pipe from entering a condition of lock-up inside a small diameter annulus.

34. The system of claim 29, wherein the electronic optical signal monitoring instrument is an Optical Time Domain Reflectometer strain measurement instrument

35. The system of claim 29, wherein the electronic optical signal monitoring instrument is an Optical Frequency Domain Reflectometer strain measurement instrument.

36. The system of claim 29, wherein the electronic optical signal monitoring instrument is a Bragg diffraction gratings strain measurement instrument.

37. The system of claim 29, wherein an independent longitudinal oriented optical fiber traverses back and forth along the length of the spoolable pipe to provide greater sensitivity to the measurement of strain using time of flight strain measurement instrumentation.

38. The system of claim 29, wherein the optical fiber is located along the longitudinal axis of the spoolable pipe near the exterior surface of the pipe and is rigidly attached

to the exterior surface of a metal or composite spoolable pipe using a bonding agent and the optical fiber is protected from damage by hazards imposed in the operating environment by an overlay of a polymeric or elastomeric external layer.

39. The system of claim 29, wherein the optical fibers are located along the longitudinal axis of the spoolable pipe and near the interior surface of the pipe.

40. The system of claim 29 wherein the optical fibers are attached to the interior of the spoolable pipe following the spoolable pipe fabrication by inserting a cylindrical foil carrier consisting of an outer layer of adhesive and with longitudinal optical fiber integrated into the foil followed by pressurization of the interior of the foil with a hot fluid or gas to cure the adhesive to bond the foil to the spoolable pipe.

41. The system of claim 29, wherein the optical fiber is integrated into the body of the composite spoolable pipe during manufacture.

42. The system of claim 29, wherein strain measurements are made in the region of deployment onto and off of a storage spool and provide information needed to assess the structural integrity of the spoolable steel or composite pipe.